

1 We claim:

2

3 1) A slow wave structure for a traveling wave tube,

4 said structure having:

5 a beam tunnel having an axis, a beam entrance and a  
6 beam exit;

7 a substrate including a plurality of elongate pins,  
8 each said pin having an attachment end and a beam tunnel  
9 end, said pins perpendicular to said substrate and said beam  
10 tunnel end of said pins located in said beam tunnel, said  
11 substrate including an exit aperture perpendicular to said  
12 beam tunnel, said elongate pin beam tunnel ends forming a  
13 substantially planar surface, said elongate pins having a  
14 first depth along said beam tunnel from said beam exit to a  
15 first distance from said exit aperture, and a second depth  
16 from said first distance to said beam entrance.

17

18 2) The slow wave structure of claim 1 where said beam  
19 tunnel carries an electron beam.

20

21 3) The slow wave structure of claim 1 where said beam  
22 tunnel carries electromagnetic waves having a wavelength.

23

24 4) The slow wave structure of claim 3 where said first  
25 distance is half said wavelength.

- 1
- 2       5) The slow wave structure of claim 3 where said first  
3 distance is  $(n+1)/2$  said wavelengths, where n is an integer  
4 greater than 0.
- 5
- 6       6) The slow wave structure of claim 3 where said  
7 elongate pins have a pitch less than 0.1 said wavelengths.
- 8
- 9       7) The slow wave structure of claim 1 where said output  
10 port is an aperture perpendicular to said beam tunnel.
- 11
- 12       8) The slow wave structure of claim 1 where said pins  
13 are arranged in rows perpendicular to said beam tunnel axis.
- 14
- 15       9) The slow wave structure of claim 1 where said pins  
16 are arranged in columns parallel to said beam tunnel axis.
- 17
- 18       10) The slow wave structure of claim 1 where said pins  
19 are arranged in rows and columns, said slow wave structure  
20 includes a longitudinal gap equal to one or more said  
21 columns, and said exit aperture is centered in said gap.
- 22
- 23       11) The slow wave structure of claim 1, said structure  
24 including a beam shaper having slots aligned with gaps  
25 between said pins, said beam shaper having a surface

1 substantially planar with said elongate pins beam tunnel  
2 ends.

3

4 12) A slow wave structure for a traveling wave tube,  
5 said structure supporting a plurality of wavelengths and  
6 having:

7 a beam tunnel having an axis, a beam entrance and a  
8 beam exit;

9 a substrate including:

10 a plurality of elongate pins, each said pin having an  
11 attachment end and a beam tunnel end, said elongate pins  
12 perpendicular to said substrate and said pin beam tunnel  
13 ends substantially co-planar with said beam tunnel axis;  
14 an exit aperture perpendicular to said beam tunnel;  
15 said elongate pins having a plurality of step change  
16 depths, each step change depth occurring a unique distance  
17 from said exit aperture.

18

19 13) The slow wave structure of claim 12 where said beam  
20 tunnel carries an electron beam.

21

22 14) The slow wave structure of claim 12 where said beam  
23 tunnel carries electromagnetic waves having at least one  
24 wavelength.

25

1       15) The slow wave structure of claim 14 where the  
2 distance between said step change depth and said exit  
3 aperture is half said wavelength.

4

5       16) The slow wave structure of claim 14 where the  
6 distance between said step change depth and said exit  
7 aperture is  $(n+1)/2$  said wavelengths, where n is an integer  
8 greater than 0.

9

10       17) The slow wave structure of claim 14 where said  
11 elongate pins have a pitch less than 0.1 said wavelength.

12

13       18) The slow wave structure of claim 14 where said  
14 output port is an aperture perpendicular to said beam  
15 tunnel.

16

17       19) The slow wave structure of claim 14 where said pins  
18 are arranged in rows perpendicular to said beam tunnel axis.

19

20       20) The slow wave structure of claim 14 where said pins  
21 are arranged in columns parallel to said beam tunnel axis.

22

23       21) The slow wave structure of claim 14 where said pins  
24 are arranged in rows and columns, said slow wave structure

1 includes a longitudinal gap equal to one or more said  
2 columns, and said exit aperture is centered in said gap.

3

4 22) An oscillator for radio frequency (RF) waves, said  
5 oscillator having:

6 a beam tunnel formed from a substrate, said beam tunnel  
7 having a plurality of elongate pins, said pins having one  
8 end connected to said substrate and an opposing beam tunnel  
9 end, said elongate pin beam tunnel ends substantially co-  
10 planar, said beam tunnel having, in sequence:

11 a beam tunnel entrance receiving electrons from a  
12 thermionic cathode;

13 a beam tunnel reflection end having a plurality of said  
14 elongate pins, said beam tunnel reflection end having one or  
15 more reflection regions whereby said elongate pins change  
16 depth;

17 a beam tunnel half wave section with said elongate pins  
18 having said first depth;

19 a beam tunnel exit aperture formed by a gap in said  
20 elongate pins;

21

22 a beam tunnel gain section with said elongate pins  
23 having a first depth;

24

1       a beam tunnel exit coupling said electrons to a  
2 collector;  
3        said oscillator coupling energy to said exit aperture.

4

5       23) The oscillator of claim 22 where said beam tunnel  
6 entrance includes an electron beam shaper having a surface  
7 substantially co-planar with said elongate pin beam tunnel  
8 ends.

9

10      24) The oscillator of claim 23 where said beam shaper  
11 includes slots parallel to said beam tunnel axis.

12

13      25) The oscillator of claim 22 where said beam tunnel  
14 carries an electron beam.

15

16      26) The oscillator of claim 22 where said beam tunnel  
17 carries electromagnetic waves having a wavelength.

18

19      27) The oscillator of claim 26 where the distance from  
20 said reflection region said pin depth change to said exit  
21 aperture is half said wavelength.

22

23      28) The oscillator of claim 26 where the distance from  
24 said reflection region said pin depth change to said exit

1 aperture is  $(n+1)/2$  said wavelengths, where n is an integer  
2 greater than 0.

3

4 29) The oscillator of claim 26 where said elongate pins  
5 have a pitch less than 0.1 said wavelengths.

6

7 30) The oscillator of claim 22 where said output port  
8 is an aperture perpendicular to said beam tunnel.

9

10 31) The oscillator of claim 22 where said pins are  
11 arranged in rows perpendicular to said beam tunnel axis.

12

13 32) The oscillator of claim 22 where said pins are  
14 arranged in columns parallel to said beam tunnel axis.

15

16 33) The oscillator of claim 22 where said pins are  
17 arranged in rows and columns, said oscillator includes a  
18 longitudinal gap equal to one or more said columns, and said  
19 exit aperture is centered in said gap.

20

21 34) The oscillator of claim 22, said reflection region  
22 comprising a plurality of pin depths having a plurality of  
23 said pin depth changes, each said pin depth change being  
24  $(n+1)/2$  wavelengths from said exit aperture, where n is an  
25 integer greater than 0.

1

2       35) An amplifier for radio frequency (RF) waves, said  
3       amplifier having:

4           a beam tunnel formed from a substrate, said beam tunnel  
5       having a plurality of elongate pins, said pins having one  
6       pin end connected to said substrate and an opposing beam  
7       tunnel pin end, said elongate pin beam tunnel pin ends  
8       substantially co-planar, said beam tunnel having, in  
9       sequence:

10          a beam tunnel entrance receiving electrons from a  
11       thermionic cathode;

12          a beam tunnel input reflection section, said elongate  
13       pins having one or more first depths;

14          a beam tunnel input half wave section with said  
15       elongate pins having a second depth;

16          a beam tunnel input aperture formed by a gap in said  
17       elongate pins having said second depth;

18          a beam tunnel wave section with said elongate pins  
19       having said second depth;

20          a beam tunnel exit aperture formed by a gap in said  
21       elongate pins having said second depth;

22          a beam tunnel half wave section with said elongate pins  
23       having said second depth;

24          a beam tunnel reflection end having a plurality of said  
25       elongate pins, said beam tunnel reflection end having one or

1 more reflection regions whereby said elongate pins change  
2 said depth;

3 a beam tunnel exit coupling said electrons to a  
4 collector.

5

6 36) The amplifier of claim 35 where said beam tunnel  
7 entrance includes an electron beam shaper having a surface  
8 substantially co-planar with said elongate pin beam tunnel  
9 ends.

10

11 37) The amplifier of claim 35 where said beam shaper  
12 includes slots parallel to said beam tunnel axis.

13

14 38) The amplifier of claim 35 where said beam tunnel  
15 carries an electron beam.

16

17 39) The amplifier of claim 35 where said beam tunnel  
18 carries electromagnetic waves having one or more  
19 wavelengths.

20

21 40) The amplifier of claim 35 where said beam tunnel  
22 carries electromagnetic waves having a plurality of  
23 wavelengths, and said input reflections section includes a  
24 plurality of said pin said first depths which have an

1 associated  $F_{\text{maximum}}$  which exceeds at least one of said  
2 wavelengths.

3

4       41) The amplifier of claim 40 where the separation  
5 between said input aperture and the change from said second  
6 depth to said one or more first depths is  $(n+1)/2$  said  
7 wavelengths for at least one said wavelength, where n is an  
8 integer greater than 0.

9

10      42) The amplifier of claim 39 where said elongate pins  
11 have a pitch less than 0.1 of at least one of said  
12 wavelengths.

13

14      43) The amplifier of claim 35 where at least one of  
15 said input aperture or said output aperture is an aperture  
16 perpendicular to said beam tunnel.

17

18      44) The amplifier of claim 35 where said pins are  
19 arranged in rows perpendicular to said beam tunnel axis.

20

21      45) The amplifier of claim 35 where said pins are  
22 arranged in columns parallel to said beam tunnel axis.

23

24      46) The amplifier of claim 35 where said pins are  
25 arranged in rows and columns which include a longitudinal

1 gap equal to one or more said columns, and said exit  
2 aperture is centered in said gap.

3

4 47) The amplifier of claim 35, including a beam shaper  
5 having slots aligned with gaps between said pins, said beam  
6 shaper having a surface substantially planar with said  
7 elongate pins beam tunnel ends.

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